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Cover Crop and Sod Plus Mulch Orchard Soil Management

C. W. Ellenwood and T. E. Fowler

Delicious at the beginning of the fifteenth year, May, 1929. Left, cover crop plot; right, sod mulch

OHIO
AGRICULTURAL EXPERIMENT STATION
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COVER CROP AND SOD PLUS MULCH ORCHARD SOIL MANAGEMENT

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Introduction

This publication presents the record of performance for the first 30 years of the life of Apple Orchard C at the Ohio Agricultural Experiment Station. Tree growth, yield records, color and size of fruit, and the cost of operation from the time the trees were planted through the thirtieth year are included in this report. The proceeds from the sale of fruit are also given.

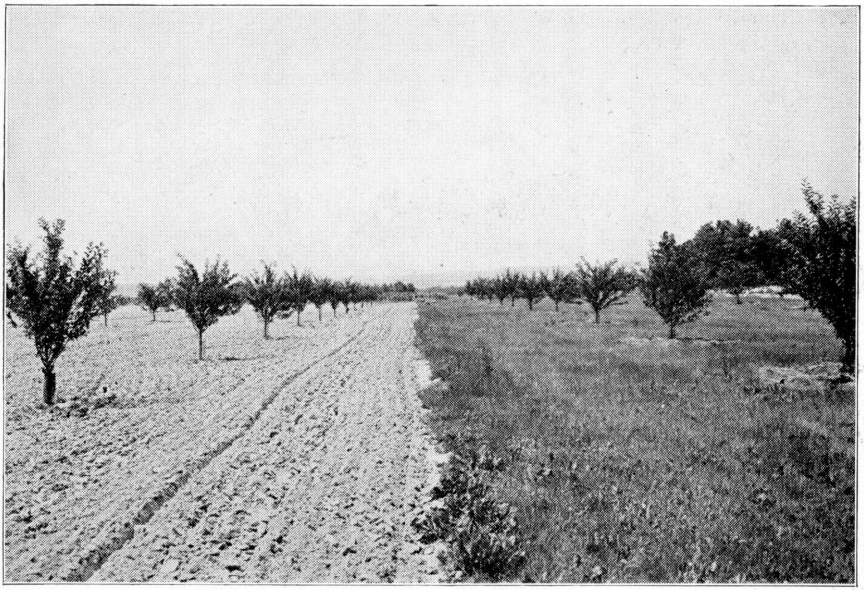

Fig. 1.—Orchard C during fourth growing season. Left, cover crop plot before seeding; right, sod mulch plot

Reports concerning this orchard, similar in nature to this publication, were made at the end of the tenth, fifteenth, and twentieth growing seasons.[1 2 3] The period covered by this report, the first 30 years, probably embraces the period when the fruit was produced the most economically. The orchard was planted in 1915 on a site which had been a pasture for many years. The predominating grass in the sod covering the field was bluegrass. The elevation is 1,070 to 1,080 feet above sea level. The soil is Wooster Silt Loam and the slope is gently eastward.

The orchard was planted for a continuation of studies comparing the cover crop system with that of the sod plus mulch plan of orchard management. Comparative operating costs for these two systems of soil management were kept throughout the period.

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[1]Ellenwood, C. W. 1925. Cost of growing apple trees under tillage and grass mulch management. Ohio Agr. Exp. Sta. Bimo. Bull. 10: 109 and 110.

[2]Ellenwood, C. W. 1930. The cost of developing an apple orchard. Ohio Agr. Exp. Sta. Bull. 456.

[3]Ellenwood, C. W., and J. H. Gourley. 1937. Cultural systems for the apple in Ohio. Ohio Agr. Exp. Sta. Bull. 580.

Description of Treatments

Two varieties were included in the orchard, 24 trees each of Delicious and Stayman Winesap.[1] There were four rows of 12 trees, running north and south. The planting distance was 35 feet by 35 feet on the square plan. The Stayman trees were uniform 2-year-old trees of medium size and the Delicious, 1-year whips when planted.

Cover Crop Plot

Half of the area was plowed before the trees were set and throughout the life of the orchard this section was maintained in cultivation. Two cover crops, usually rye and soybeans, were grown annually. A heavy disk was used to work the cover crop into the soil.

Fig. 2.—Disking under heavy growth of Sudan grass, cover crop plot, Orchard C

Sod Mulch Plot

On the other section of the orchard, the trees were planted in the sod and this plot was kept in sod for the entire 30-year period. The grass grown in the orchard over the entire period, as well as other organic material, was used to maintain a heavy mulch beneath the trees. With the exception of some hoeing around the base of the trees in the earlier years to reduce the rodent hazard, no cultivating implement was used on this plot.

Wheat straw was used for mulch and it was applied only as often as needed to maintain a mulch 3 to 6 inches in depth. Not more than 2 years elapsed between applications of mulch.

For the purpose of brevity, this section is frequently referred to in this publication as the "Mulch Plot."

[1]For the sake of brevity, Stayman Winesap is hereafter referred to as Stayman.

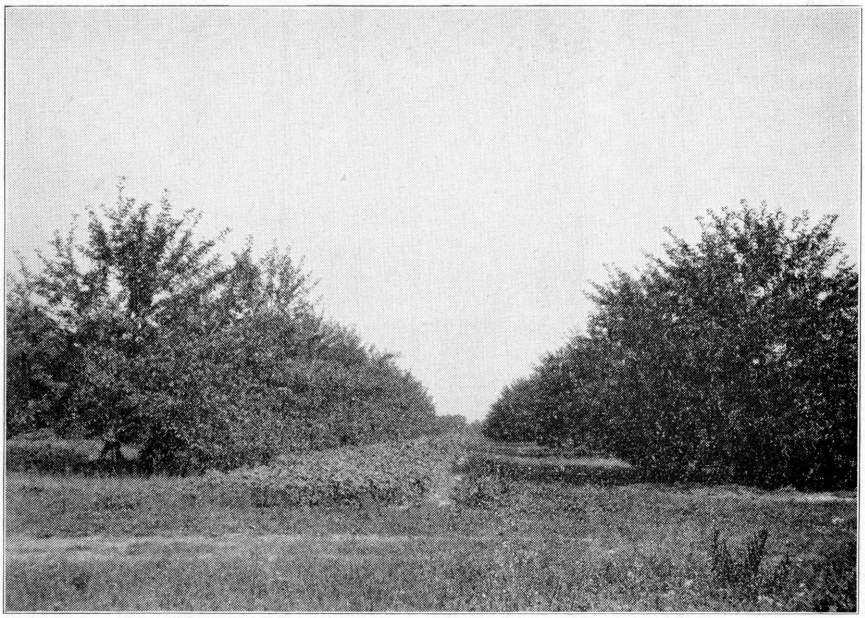

Fig. 3.—Orchard C, 11 years from planting. Left, cover crop plot soybeans, right, mulch plot.

Pruning

Both sections of the orchard received the same type and degree of pruning annually throughout the 30 years. In the earlier years, a rather light pruning was given consisting mainly of removing the interfering branches. During the period from the twentieth to thirtieth years, somewhat heavier pruning was practiced with more attention given to a detailed thinning out of the unproductive wood in the interior part of the trees and from the lower branches.

An effort was made to train the trees to the modified central leader type and they developed a fairly uniform structure. The angles of the crotches of the lateral limbs were much more acute with Delicious than Stayman but the type of soil management practiced had no influence on the shape of the tree. During the period from the twenty-fifth to thirtieth years, some heading back of the trees was required to keep the height at 20 feet or less.

Thinning

Hand thinning was required several years to enable the remaining fruit to attain reasonable size. An effort was made to thin each plot to the same degree in any given year. The Stayman trees required heavier thinning than the Delicious.

Fertilizers

Chemical fertilizer was not applied to either plot during the first 8 years; however, beginning with the ninth year, half of each plot received an annual application of nitrogenous fertilizer. The fertilizer treatment was applied

crosswise to the soil management treatment. The fertilized section was divided into two plots of 12 trees each. One of these was fertilized annually with nitrate of soda applied at the rate of ¼ pound for each year of the trees age per tree. The other plot was fertilized with sulfate of ammonia, used at the equivalent rate of nitrogen per tree.

These nitrogenous fertilizers were applied broadcast on the surface of the ground under the trees in late March or early April. In the mulched area, the fertilizer was scattered on top of the mulch. In the spring of 1941, an overall application of a mixed fertilizer was broadcast over the entire area of both plots for the purpose of stimulating better growth of grass on the sod mulch plot and of cover crops on the other plot. This mixed fertilizer was a home-made mixture of sulfate of ammonia, superphosphate, and muriate of potash of approximately a 4-12-10 ratio and was used at the rate of 300 pounds per acre.

Results from Use of Fertilizer

So far as fruit production was concerned, no benefit was derived from the use of the nitrogenous fertilizer on either plot or on either of the two varieties. The foliage on the trees in the fertilized section has sometimes been of a darker green hue than on the unfertilized section. This was especially true in dry seasons.

Following the overall application of the mixed fertilizer both the grass in the mulched area and the cover crops, particularly the soybeans, made better growth. At the end of 30 years, it cannot be said that the production record or tree measurements indicated the need for fertilizer. In this connection it may be well to emphasize that the same soil management practices in each of the plots had been consistently followed throughout the 30-year period.

Size of Trees

Data on the size of the trees are presented in tables 1, 2, and 3. Three measurements were made as indices of tree size; (1) circumference of the trunk, (2) height of the trees, and (3) diameter of the head of the tree.

Circumference of the Trunk

The circumference of the trunk of each tree, 12 inches above the ground, was measured at frequent intervals during the 30 years. Measurements taken at six different times during the life of the orchard are shown in table 1. It will be noted that at the end of the 30-year period there was practically no difference in tree circumference so far as the two soil treatments were concerned. The Delicious trees were about 6 inches larger in circumference than the Stayman at 30 years from planting.

TABLE 1.—Circumference of tree trunk

Variety	Soil treatment	Circumference of trunk in inches at 12 inches above ground					
		1916	1922	1930	1934	1937	1944
Stayman.....	Cover crop	3.50	16.62	31.56	33.83	39.85	43.62
Stayman.....	Mulch	3.53	16.41	32 81	38.09	41.68	44.17
Delicious	Cover crop	3.10	15.64	32.42	37.91	41.48	49.00
Delicious	Mulch	3.04	14.99	32.54	39.26	43.42	50.75

Height of Trees

The height of the trees taken at five different times is shown in table 2. Here again there has been no significant difference between the two plots. It is of interest to note that both varieties on both plots had reached about 20 feet in height by 1937, 23 years after planting. From that time on an effort was made to restrict the height of the trees to 20 feet and the data given for 1944 in table 2 show that this has been uniformly accomplished.

TABLE 2.—Height of trees

Variety	Soil treatment	Height of trees in feet				
		1923	1929	1934	1937	1944
Stayman	Cover crop	15.30	17.95	19.21	19.67	19.50
Stayman	Mulch	14.79	17.86	20.36	20.14	18.83
Delicious	Cover crop	14.33	16.83	19.50	18.77	18.95
Delicious	Mulch	14.12	17.50	19.96	19.92	18.09

Diameter of Head of Trees

The diameter of the head shown in table 3 represents an average of two measurements of each tree. One measurement being from north to south and the other from east to west. Very little pruning back of the lateral growth of the trees was done at any time. The figures given in table 3, taken at 5 intervals during the 30-year period, show that the trees on the two plots have always had about the same spread.

TABLE 3.—Diameter of head of trees

Variety	Soil treatment	Diameter of head in feet				
		1923	1929	1934	1937	1944
Stayman	Cover crop	19.30	22.90	26.68	27.34	27.65
Stayman	Mulch	18.79	21.98	27.86	28.64	27.71
Delicious	Cover crop	17.33	23.65	28.86	29.20	29.50
Delicious	Mulch	16.75	22.99	29.12	29 65	29.86

Influence of Soil Management

Date of Bloom

Mulching has sometimes been suggested as a means of retarding the development of fruit tree blossoms. This opinion probably originates from the common observation that blossoms of low-growing plants like strawberries may be delayed by means of a mulch.

Individual tree records were taken of the date of bloom in Orchard C each year after the trees began to bloom. A summary of these data is presented in table 4. The average date of full bloom for the Stayman was May 8 and for Delicious, May 9 on each plot.

It may be safely concluded that the normal development of the blossoms was not influenced by either method of culture. This experience in Orchard C is in conformity with observations made in other orchards at the Station, over an even longer period of time.

TABLE 4.—Date of full bloom, 1922-1944

Variety	Soil treatment	Date of full bloom. Average for 23 years
Stayman	Cover crop	May 8
Stayman	Mulch	May 8
Delicious	Cover crop	May 9
Delicious	Mulch	May 9

Frost Penetration

The temperature of the surface soil is materially influenced by the cultural treatment used. To what extent extreme soil temperatures are undesirable was not investigated at this time. It is well known that if extremely low temperatures occur when the ground is unprotected by snow or some other insulating material, root killing will occur. If, on the other hand, the soil temperature becomes high during the summer, the rate of moisture loss is higher. The more equitable temperature under the mulch would seem to be most favorable for the trees.

From table 5 it will be seen that the soil under the mulched trees did not freeze so deeply as that under the cultivated trees during the severe winters of 1933-1934, 1935-1936, and the mulch milder temperatures during the winter of 1941-1942. Two examinations were made in February 1936, the first on February 3 and the second was made, after an especially cold period, on February 26. The observations taken March 3, 1934, February 26, 1936, and on February 28, 1942 represent the maximum frost penetration in these respective years.

TABLE 5.—Influence of soil management on depth of frost penetration

Soil treatment	Depth of penetration in inches			
	Mar. 3, 1934	Feb. 3, 1936	Feb. 26, 1936	Feb. 28, 1942
Heavy straw mulch	3.0	3.0	9.0	Trace
Sod not mulched	9.5	7.0	18.0	3.0
Cover crop	10.5	11.0	30.0	9.0

It is not suggested here that the deeper freezing of the soil in the cultivated area had an injurious effect on the trees in this particular orchard. However, these data do throw some light on the value of straw mulch in preventing deep frost penetration.

Yield of Fruit

The total production of fruit for the first 30 years of the life of this orchard is shown in tables 6 and 7. In table 6, the production is shown on the basis of the average weight of fruit produced per tree for the period. In table 7, the production is shown on the basis of yield per acre in bushels. For the purpose of this latter table, 48 pounds is considered a bushel. Individual tree yields were recorded beginning in 1921 when the first fruit was produced.

TABLE 6.—Total production of fruit per tree, 1921-1944

Plot	Variety	Average total per tree	Average production per year
		Lb.	*Lb.*
Cover crop	Stayman	13,522	563
Cover crop	Delicious	10,116	421
Mulch	Stayman	12,231	509
Mulch	Delicious	10,903	454

Production per Tree

It will be noted by reference to table 6 that the average production per tree on the Stayman trees on the cover crop plot exceeded that of the mulch plot by 54 pounds per year. In the case of Delicious, the average annual production per tree was 33 pounds greater on the mulch plot. These data seem to indicate that the two varieties responded somewhat differently to these two types of soil management. This difference was also noted (3) at the end of the twentieth year. Differences in yields between the plots cannot be said to be significant.

Production per Acre

In table 7, the annual yield per acre, beginning with 1921 and continuing through 1944, is shown.

Stayman came into production earlier than Delicious on both plots.

By reference to table 7 it will be seen that the average annual yield per acre of Stayman on the cover crop plot from the eleventh to the twentieth years was 371.0 bushels; whereas, the yield on the mulch plot was 275.4 bushels. During the same period, Delicious had a yield of 322.9 bushels per acre on the cover crop plot and 342.0 bushels on the mulched plot.

Much the same relationship between the varieties was shown for the last 10 years of the 30-year record, when the Stayman on the cover crop plot had an average annual yield record of 499.2 bushels per acre as against 406.7 bushels from the mulch plot. During this same period for 1935 to 1944, the Delicious on the cover crop plot produced at the rate of 370.6 bushels per acre as against 456.2 bushels on the mulch plot.

When the two treatments are considered together the Delicious had a slightly higher production during the first of these two 10-year periods, while Stayman outyielded Delicious during the last 10-year period by about 39 bushels per acre.

The yields recorded for both varieties are relatively high for this State and, regardless of the soil management treatment, would be considered highly satisfactory. The results shown in table 7 indicate that mulch was conducive to higher yields with Delicious than with the Stayman.

Regularity of Production

It will be seen by reference to table 7 and figure 4 that both varieties and both plots were comparatively regular in annual production, after the trees reached bearing age.

Low yields due to frost injury were recorded on both plots in 1928. In 1929 and again in 1943, weather for pollination was unfavorable and the yields

TABLE 7.—Yield per acre, Orchard C, 1921-1944

Year	Cover crop plot			Mulch plot			Yield per acre for entire orchard in bushels		
	Stayman	Delicious	Average	Stayman	Delicious	Average	Stayman	Delicious	Average
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
1921	40 0	.0	20.0	34 7	.8	17 7	37.3	.4	18.8
1922	65 0	10.5	37.7	76.8	11.1	43.9	70.9	10.8	40.8
1923	96 9	42.2	69.5	150 9	49 5	100.2	123.9	45.8	84.8
1924	153 2	56.9	105.0	92.1	31 7	61.9	122.6	44.3	83.4
1925	196.0	247.5	221.7	133.9	183 9	158 9	165.0	215.7	190.3
1926	440 1	315.5	377.8	295.9	208.5	252.2	368.0	262.0	315.0
1927	333.4	339.5	336 5	165.6	297.8	231.7	249.5	318.7	284.1
1928	176.3	89.3	132.8	110.1	83.8	96.9	143.2	86.6	114.9
1929	352.6	101.7	227.2	267.3	81.2	174.2	309.9	91.5	200.7
1930	482.7	396.4	439.6	288.4	316.9	302.6	385.5	356.7	371.1
1931	521.0	526.2	523.6	454.1	633.2	543.6	487.5	579.7	533.6
1932	483.5	394.3	438.9	285.9	559.7	422.8	384.7	477.0	430.8
1933	445.2	258.4	351.8	458.6	263 1	360.8	451.9	260.8	356.3
1934	279.2	560.5	419.9	294.3	792.0	543.1	286.7	676.3	481.5
1935	525.7	465.1	495.4	384.3	515.0	449.6	455.0	490.1	472.5
1936	405.9	421.7	413.8	382.2	641.6	511.9	394.0	531.7	462.8
1937	382 0	261.4	321.7	351.7	225 8	288.7	366.8	243.6	305.2
1938	499.9	455.5	477.7	154.8	613.0	383 9	327.3	534.3	430.8
1939	676.4	536.9	606.6	597.1	626.3	611.7	636.7	581.6	609.1
1940	487.7	279.0	383.3	408.2	420.2	414.2	447.9	349.6	398.7
1941	418.8	373.2	396.0	473.6	351.7	412.6	446.2	362.4	404.3
1942	544.1	286.6	415.3	392.2	527.3	459.7	468.1	406.9	437.5
1943	438.2	170.3	304.2	379.3	105.7	242.5	408.7	138.0	273.3
1944	613.5	456.3	534.9	543.3	535.8	539.5	578.4	496.0	537.2
1925 to 1934, average annual yield	371.0	322.9	347.0	275.4	342.0	308.7	323.2	332.5	327.8
1935 to 1944, average annual yield	499.2	370.6	434.9	406.7	456.2	431.4	452.9	413.4	433.1

on both plots were much below the average. Notes taken during and subsequent to full bloom for this period show that unfavorable weather for pollination was a more serious factor in reducing yields than spring frost.

Throughout the entire period ample bees were present at bloom time to insure pollination. A prolonged period of cold rainy weather during bloom prevented bee activity in both 1929 and 1943. In both years this same sort of weather continued past the bloom period to provide conditions unfavorable for the development of the fruit where pollination had occurred.

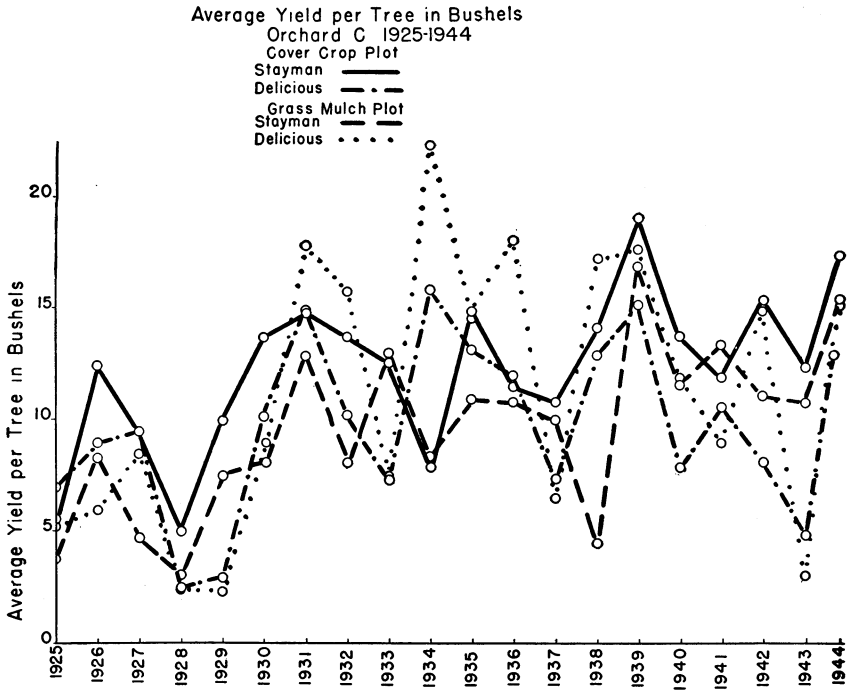

Fig. 4.—Chart showing fluctuation in yield per tree from 1925 to 1944.

Highest prduction for this 30-year period on Stayman (both plots) was reached in 1939, the twenty-fifth year from planting. Delicious reached peak production on both plots in 1934, the twentieth year from planting.

In making the foregoing observations, the writers do not wish to imply that the production records of these varieties in this orchard are to be taken as typical of what might be expected generally. Peak production for many varieties of apples is not reached until after the thirtieth year. It is also well to remember that although Delicious reached peak production earlier than Stayman during this 30-year period, the latter variety came into production earlier than Delicious.

Delicious showed more of a tendency to alternate heavy and medium to light crops than did Stayman.

Size of Fruit

During the 15-year period, 1930 to 1944 (table 8), the Stayman fruits grown on the mulch plot have been consistently larger than on the cover crop section. The Delicious have also averaged larger on the mulch plot than on the cover crop. Three size grades were made annually of both varieties for this 15-year period. It will be seen by reference to table 8 that there is a much greater difference in the size of the fruit with Stayman than Delicious for the two plots. This size difference in the Stayman in favor of the mulch plot has tended to partially offset the advantage in yield of this variety on the cover crop section.

TABLE 8.—Size of fruit, 1930-1944

Variety	Soil treatment	Above 2¾ inches	2¼ to 2¾ inches	Below 2¼ inches
		Percent	*Percent*	*Percent*
Stayman	Cover crop	54.7	41.7	3.6
Stayman	Mulch	78.5	20.4	1.1
Delicious	Cover crop	80.7	18.7	.6
Delicious	Mulch	89.5	10.1	.4

There was much less difference in the size of the Delicious fruits on the two plots than in the case of Stayman. Assuming a price range for Stayman for the different sizes of 2½, 1½, and ¾ cents per pound, respectively, the difference in the aggregate value of 100 pounds of apples from each plot would have been 9 cents in favor of the mulched plot. A higher price range or a greater differential between size grades would of course make the difference in aggregate values more. The difference in size of the fruit grown on the two plots was greater than the color factor. It was apparent that the higher moisture level of the soil in the mulch section was responsible for the larger fruit.

During the picking season of 1944, which had been a very dry year, some observations were made on the number of Stayman fruits in a 50-pound field crate. The average number of apples, "tree run", from the Stayman trees on the cover crop section was 245 while on the mulch plot the average was 191 apples per crate. It should be emphasized here that the size of the Stayman fruit on the mulch plot, while significantly larger than that from the cover crop section, by no means compensated for the greater yield from the latter. This is a fact to be kept in mind when appraising the influences of cultural practices on such grade factors as size and color. Total yield per tree is the most important economic factor with varieties of apples which normally produce medium sized fruit.

Color of Fruit

Color grades of the fruit from the two plots over a 15-year period are shown in table 9. The color was uniformly high throughout the period. The fruit from the cover crop plot, both Stayman and Delicious, had slightly better color than on the mulch plot; however, the difference could hardly be considered significant for either variety.

It is apparent that the influence of the type of soil management practiced had much less influence on color than on either yield or size of fruit.

TABLE 9.—Color of apples, 1930-1944

Variety	Soil treatment	Color grade		
		U. S. Fancy*	U. S. No. 1†	Below U. S. No. 1
		Percent	*Percent*	*Percent*
Stayman	Cover crop	80.9	14.4	4.7
Stayman	Mulch	77.3	15.7	7.0
Delicious	Cover crop	87.9	9.6	2.5
Delicious	Mulch	81.2	12.4	6.4

*U. S. Fancy color requirement: Stayman over 33⅓ percent, Delicious over 50 percent.
†U. S. No. 1 color requirement: Stayman over 15 percent, Delicious over 25 percent.

It is worth noting that the data shown in table 9 covers the sixteenth to thirtieth years of the life of this orchard and probably embraces the period of highest color and optimum production. The color grades shown in this table would likely tend downward as the trees grow older.

Growing Costs Compared

The growing costs of the cover crop plot for the 30-year period are shown in appendix table I and those for the mulch plot in appendix table II. The two varieties are grouped together for the data included in these tables.

Some explanation concerning the methods of compiling these costs is necessary for the reader to properly interpret the results.

In making comparisons between these two systems of soil management it should be emphasized that this orchard was located on good soil where tree roots penetrate rather deeply and where the soil fertility level was reasonably high at the start. The land is nearly level and there is little erosion. Moreover the comparison in soil management is simply between two good systems of handling apple orchard soils. It is regretted that records of the behavior of a like number of trees, planted in sod where the only mulch used around the trees was that grown in the orchard, was not available for comparison. It is also doubtless true that the mulch used was heavier than was necessary but no comparative plots where smaller amounts were applied were included in these tests. This small orchard has been developed as a single unit of the entire acreage (ranging from 40 to 55 acres) of orchards at the Station. Costs of materials, labor, and equipment are therefore based on similar items prevailing in a commercial orchard of approximately 50 acres. The average annual production cost per tree for the 30-year period was $4.524 for the cover crop plot and $4.521 for the mulch plot.

Items Not Included in Costs

The major items of cost are included in these records, but it should be pointed out that some overhead costs such as the maintenance of the water supply for spraying, upkeep of buildings, the tiling of the orchard in 1924, and some minor items which properly should be charged against the operating costs are not included in these costs.

No effort has been made to place an inventory value on the trees during or at the end of the 30-year period. It is worth noting that 40 of the original 48 trees were still in good vigor at the end of this period and that 7 of the 8 trees lost had been in good production for 10 years or more.

Man Labor

The hourly rate of pay as shown in appendix tables I and II was the prevailing rate paid for farm labor in the region of the Experiment Station for this period of time. Supervision is considered apart from labor.

Team and Tractor Costs

The motive power used in the orchard during the early years was either a team or a single horse. In later years, a tractor was used to supply most of the power, except for mowing and raking.

Cost of Tree

The trees were planted at a time (1915) when nursery stock was very cheap as compared with prices for comparable trees at the end of the 30-year period. The original cost of nursery stock is a very minor matter in the total cost of growing apples in a productive orchard.

Pruning Costs

Pruning was one of the major items of expense in this orchard. Some pruning was done every year except in 1918. As has already been pointed out the pruning was very light during the earlier years, but somewhat heavier during the last 10 years. The disposition of the brush from the pruning operation in this orchard was unavoidably more expensive than might be expected in a large commercial orchard where a power driven brush rake or burner would be available.

Cost of Mulch and Cover Crop

Most of the straw used in mulching this orchard was from nearby straw stacks, generally hauled unbaled to the orchard by team and wagon. The straw was used at the rate of from 100 to 200 pounds per tree annually during the last 10 years. The amount of mulch applied was regulated to some extent by the rate of decomposition of the mulch. A charge was always affixed for the mulch, in addition to the cost of hauling and distribution. This charge was determined by the prevailing price of loose straw, taking into consideration the quality of the material used. It will be noted that the cost of mulch and its application, plus mowing, represented 14.60 percent of the total production costs on the mulch plot for the 30-year period; whereas, the cost of cultivation plus the cover crop seed on the cover crop plot amounts to 12.29 percent.

In addition to the foregoing comparisons concerning the cost of the cover crop and mulch systems as practiced in this orchard, the writers want to add the following observations.

Mowing the orchard, it will be noted, comprised a relatively small part of the total cost of the soil management operations on the mulch plot. This is pointed out here because the charge shown for the item, "mowing, man and team", would be more comparable with the cultural costs as found in the average commercial orchard in this State. Most Ohio orchards are grown in sod and mowed; but few of them are actually mulched in the manner of Orchard C. Thus, if we consider only the charge for mowing the orchard and applying the mulch grown in the orchard, then the cost would be much less than for the cover crop system of soil management.

In nearly every year, two cover crops were grown annually and the prevailing price for the seed was charged. Two years, Sudan grass was substituted for the usual summer cover of soybeans, and in one year, field corn,

drilled with a wheat drill with all hoes open, was used as a summer cover crop. The winter cover was rye. It may be suggested that the cost of cultivation, plus the cover crop seed and drilling, shown in appendix table I is unduly high. For instance, it is doubtless true that in a commercial orchard where cultivation is practiced, many growers would be satisfied with turning under one cover crop a year, thus reducing the total cost.

Fig. 5.—Sod mulch plot showing mulch extending outward beyond spread of trees. Trees 20 years old.

It is believed that the comparative charges for mulch and cover crops shown in appendix tables I and II constitute a fair presentation in the case of this orchard where both systems of soil management were rigidly followed for 30 years. These figures show definitely that mulching, as it was practiced here, is not cheaper than cultivation with cover crops. Of course, during the first 10 years of the life of the orchard when the trees were smaller and more mulch was grown in the orchard, the cost of mulching was appreciably less than cultivation.

Cost of Spraying

For the 30-year period, spraying charges amounted to 23.07 percent of the total production costs in the cover crop plot and 23.44 percent on the mulch plot. Both plots were always sprayed at the same time and with the same material. The number of applications per year ranged from 1 for the first 5 years, to as many as 11 in 1937. During the last 15 years of the period, the number of applications per year has generally ranged from six to nine, depending upon the seasonal requirements for good control of pests.

Spraying was by far the largest single item of cost. The charges for spraying were based on efficient operation of high powered sprayers throughout the period and are representative of what might be expected in well sprayed commercial orchards subjected to a similar range of orchard pests.

Apple scab and two broods of codling worms were the two most serious pests to be controlled. Such insects as scale, apple flea weevil, red mite, and red bug were of minor importance. At the end of the period, the average amount applied per tree was in the neighborhood of 24 gallons per application.

Cost of Fertilizer

Only half the trees in each plot were given the customary annual application of nitrogenous fertilizer and these received no fertilizer until the beginning of the ninth year. Thus, the average cost per tree for the whole orchard is very low. The over-all application of complete fertilizer to the entire orchard in 1941 accounts for the higher fertilizer cost for that year. It is well to point out here that the cost of fertilizer for the average commercial orchard is comparatively low when the total costs are considered.

Interest and Taxes

The method of computing the amount charged for interest and taxes has been described in a previous publication (2). The original value of the land was figured at $125 per acre. Interest on the original investment was at the rate of 6 percent and the taxes were estimated at the rate prevailing in the township where the orchard is located.

Thinning, Picking, Hauling, and Grading

These charges were all calculated on labor charges prevailing in the community for such work during this period.

Rental of Crates and Small Tools

Since this block of trees was being operated as a unit of a larger orchard, it seemed best to make a rental charge for use of crates and such small tools as pruning shears, saws, ladders, hoes, thinning shears, forks, and picking containers. Hence, the amount shown under this item represents the proportional share of the expense of such items for the entire acreage of orchard under operation.

Supervision

This charge is based on the share of the time of the foreman of the Station orchards and gardens consumed in the general supervision of this orchard. No charge has been made for the time of the members of the scientific staff spent on this special project. It is important to keep in mind that figures used in calculating such charges as supervision are very local in their application.

Relative Importance of Items of Cost

It will be noticed by reference to appendix table I that items of cost on the cover crop plot ranked in the following order: (1) Spraying, with 23.07 percent of the total costs for the 30-year period; (2) harvesting, including picking and transportation to packing shed, 14.97 percent; (3) cultivation and cover seed, 12.29 percent; (4) pruning and disposing of brush, 10.95 percent; (5) interest and taxes, 9.39 percent; (6) supervision, 8.34 percent; and (7) grading, 7.52 percent. These seven items accounted for 86.53 percent of the total cost of growing, harvesting, and grading the apples on the cover crop plot. It should be emphasized that these costs do not include charges for storage or marketing.

The costs on the mulch plot (appendix table II) ranked as follows: (1) Spraying, with 23.44 percent of the total growing costs; (2) mulch, including cost and application of mulch and mowing, 14.60 percent; (3) harvesting 14.38 percent; (4) pruning and disposing of brush, 11.23 percent; (5) interest and taxes, 8.79 percent; (6) supervision, 8.39 percent; and (7) grading, 7.23 percent. These seven major items of cost comprise 88.06 percent of the total growing costs on the mulch plot.

Value of Fruit per Tree

The value of the total amount of fruit produced per tree for the period from 1921 to 1944, is shown in table 10. The varieties are grouped together in this table. The value of the fruit is based on the actual production and grade records from year to year and the prevailing price for apples sold at the packing house. These values do not include package and storage charges. Of course, the value of the fruit per tree is related to both quantity and quality of the apples produced. In this particular orchard, the data presented indicate that both the amount of fruit per tree and the quality were above average.

TABLE 10.—Value of fruit per tree, 1921-1944.
Varieties—Stayman and Delicious

Plot	1921	1922	1923	1924	1925	1926	1927
Cover crop.....	.83	1.60	2.66	5.61	11.56	14.59	16.83
Mulch.....	.73	1.86	4.01	3.62	9.61	10.72	13.25
Plot	1928	1929	1930	1931	1932	1933	1934
Cover crop.....	7.45	16.30	24.98	13.69	13.68	11.53	14.27
Mulch.....	6.29	14.30	19 16	15.21	13.59	11.94	18.79
Plot	1935	1936	1937	1938	1939	1940	1941
Cover crop.....	14.26	19.92	7.64	22 47	9.35	10.74	9.12
Mulch.....	12.75	24.81	6.90	18.37	10.25	12.58	10.05
Plot	1942	1943	1944	Total		24-year average	
Cover crop.....	13.37	19.38	22 60	304.43		12.685	
Mulch.....	15.30	14.41	25.90	294.40		12.267	

The price per bushel received at Wooster, for the Delicious and Stayman grown in this orchard during the period from 1921 to 1944, is shown in table 11. In evaluating the data shown in table 10, it is well to keep in mind that the average color and size of the apples was excellent throughout the period. Moreover, fruit of good quality of these two varieties commands prices higher than the average for the standard varieties in the Wooster area. The price range shown in table 11 is in harmony with prices received by nearby commercial growers over a like period of time for these two varieties.

Some explanation concerning the prices received for the apples during this period may help to interpret the data presented in table 11. The grades, for the purpose of record, are listed as number 1, number 2, number 3, and culls.

TABLE 11.—Price per bushel received for apples at Wooster, 1921-1944. (Bushel—48 pounds)

Year	Stayman				Delicious			
	Grade				Grade			
	No. 1	No. 2	No. 3	Culls	No. 1	No. 2	No. 3	Culls
	Dol.	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*
1921	1.75	1.00	.....	0.40	.....	.....	.....	.....
1922	1.75	1.25	.75	.40	1.75	1.25	.75	.40
1923	1.50	1.00	.....	.50	1.50	1.00	.....	.50
1924	2.00	1.50	1.00	.50	2.00	1 50	1.00	.50
1925	1.75	1.25	.....	.35	2.00	1.50	.....	.35
1926	1.35	.85	.....	35	1.50	1.00	.....	.35
1927	2.00	1.25	.75	.35	2.00	1.25	.75	.35
1928	2.00	1.50	1 00	.50	2.00	1.50	1.00	.50
1929	2.50	2.00	1.25	.70	2.75	1.75	1.25	.70
1930	2.25	1.70	1.25	.50	2.50	2.00	1.50	.50
Average 1921-1930	1.88	1.33	1.00	.46	2.00	1.42	1.04	.46
1931	1.00	.60	.37	.12	1.25	.75	.60	.12
1932	1.25	.85	.65	.25	1.25	1.00	.75	.25
1933	1.35	1.15	.60	.30	1.50	1.25	.90	.30
1934	1.40	.90	.75	.40	1.90	1.15	.85	.40
1935	1.00	.75	.60	.25	1.10	75	60	.25
1936	1.60	1.40	1 10	.40	1.75	1.50	1.20	40
1937	.75	.60	.35	.25	1.00	.75	.60	.25
1938	1.65	1.40	.85	.50	1.65	1.40	1.00	.50
1939	.60	45	.25	.17	.75	.50	.25	.17
1940	1.25	1.00	.55	.25	1.50	1.25	.62	.25
Average 1931-40	1.18	.91	61	.29	1.36	1.03	.74	.29
1941	1.10	.75	.50	.25	1.10	.75	.50	.25
1942	1.20	.75	.50	.25	1.25	.75	.50	.25
1943	2.75	2.25	1 00	.60	3.00	2.25	1.25	.60
1944	2.50	1.50	.75	.50	2.50	1.75	.75	.50
Average 1941-1944	1.89	1.31	.69	.40	1.96	1.38	.75	.40
Average 1921-1944	1.59	1.15	.74	.38	1.65	1.24	.83	.38

The number 1 grade consisted of those apples above 2¾ inches in diameter meeting the grade requirement for U. S. Fancy, at least 33 percent color. Number 2 consisted of the apples from 2¼ to 2¾ inches in diameter meeting the grade requirement of U. S. Fancy. Number 3 consisted of the apples above 2¼ inches in diameter not meeting the U. S. Fancy requirement, except those ranging from 2¼ to 2¾ inches in diameter which had less than the color requirement for U. S. number 1. Culls in this instance consisted of all apples less than 2¼ inches in diameter, plus those between 2¼ and 2¾ inches in diameter, which had less than the U. S. number 1 color requirement.

This explanation is made for the purpose of enabling the reader to better understand tables 10 and 11. While these grades are similar to those commonly used by commercial growers and the trade, the terminology used in classifying them for the purpose of these tables is not intended to represent any specific authorized grade standard.

Table 11 covers the entire period of 24 years during which this orchard produced fruit. The prices do not include packages. It should be remembered that these two varieties, Delicious and Stayman, generally command higher prices than many other varieties. It is of interest to note that the prices received for the 10-year period from 1921 to 1930 were very similar to those received during the 4-year period 1941 to 1944. During the 10-year period from 1931 to 1940, the average price per bushel for all grades was much less than the first 10-year period or the last 4-year period. During the earlier years, most of the culls were sold to nearby farmers for making cider. In recent years, much of this grade has gone to a processing factory.

Soil Management Affects Other Orchard Practices

Movement of Orchard Equipment

It is a matter of some importance to be able to move heavy equipment, including tractor and sprayer, through an orchard in the early spring months when the soil may be excessively moist. In 5 out of the last 20 years of this 30-year period, some difficulty was experienced in pulling the heavy sprayer through the cover crop plot, due to the soft ground. On the other hand, passage of heavy equipment through the mulch section was always accomplished with ease.

Fig. 6.—Heavy spraying equipment used in recent years in spraying Orchard C.

In addition to the inconvenience occasioned by the difficulty of moving heavy equipment across the cover crop plot during wet periods, there is likely to be some injurious effect on the soil from packing by the wheels of sprayer and tractor. In this particular orchard, no injurious effect on tree growth was noticed from this source. This orchard has a line of drainage tile between each row of trees and the drainage thus provided tended to reduce the chances of impacting the soil by the use of heavy equipment.

Windfalls

No effort was made to determine the value of the windfall apples on the two plots. In a few years when there was a considerable amount of rainfall during the ripening period, the windfalls from the mulched trees were much cleaner than those from the cover crop section. This might not be a very serious matter where the fruit is run through a brushing or washing apparatus before grading.

It is to be noted, however, that generally there was much less bruising and soiling of the apples under the mulched trees than on the cover crop plot.

In only 2 years during the period covered by this report was there excessive dropping of the fruit and then there was no appreciable difference in the amount of windfalls on the two plots.

Mice and Fire Hazard

One of the objections raised to the mulch system for orchards is that in areas where field mice are abundant, these rodents constitute a serious menace to the trees. In this particular orchard, no injury was sustained either from mice or rabbits during the 30 years. In the early years, all litter was removed from the base of the trees late in the summer or early fall. Wire tree guards were used around the trees for 8 years.

The writers believe that the rodent hazard is somewhat greater in mulched orchards than in those under the cover crop system. But it is felt that by clearing all litter away from the base of the tree in early autumn and observing the accepted practices for preventing rodent injury that the danger from this source is not very great.

There is greater danger of fire in mulched than cultivated orchards, particularly in dry periods. Growers who have their trees planted in sod must recognize this hazard. The heavier the mulch under the trees, the greater is the danger.

No damage from fire has occurred at the Experiment Station in Orchard C. During especially dry periods in late summer, orchard sprayers and a supply of water have been kept ready for such an emergency.

Discussion

It should be emphasized that, as practiced in Orchard C, the cover crop system of soil management differed greatly from the clean culture plan where an effort is made to discourage the growth of weeds or grass throughout the growing season. However, the system of cover crop management used here is adaptable only to virtually level land. Commercial orchards in Ohio are generally located on rolling or hilly sites where tillage is impractical because of danger of erosion.

In recent years, a number of orchards in Ohio have been planted on a contour plan, thus permitting some cultivation, especially during the early life of the orchard.

The majority of the commercial apple orchards in this State are grown in sod and fertilized annually with an application of nitrogenous fertilizer. The growth of grass and weeds between the trees in such orchards is mowed once or twice each year. This growth may be left on the ground where it falls or it may be raked up and placed around the trees as a mulch. When this type of soil management is followed in mature orchards the resulting amount of mulching material is generally not sufficient to provide the amount of heavy mulch used in Orchard C during the 30-year period. The amount of mulch maintained was heavy enough to almost entirely eliminate the growth of grass under the trees throughout the year. The residual effect of the decaying mulch, as has been pointed out elsewhere, has apparently made the addition of nitrogenous fertilizer unnecessary in this orchard.

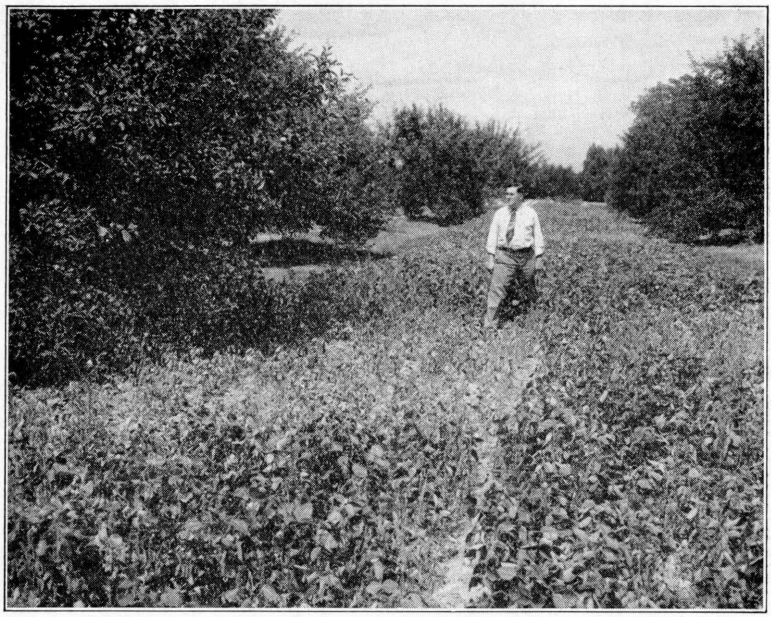

Fig. 7.—Cover crop plot in twenty-fourth year. Note effect on soybeans of competition with trees for moisture during dry season.

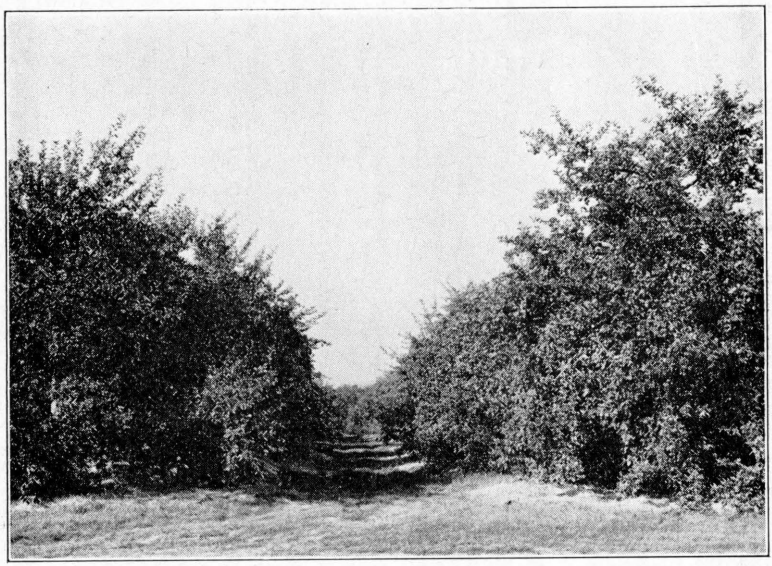

Fig. 8.—Mulch plot 1944, Delicious on left and Stayman on right.

In two nearby orchards on the same type of soil, trees grown in sod but not mulched where no nitrogenous fertilizer was applied suffered badly as compared with adjacent trees where fertilizer was applied annually. Not only

was the production of fruit per tree much less on the unfertilized trees but the mortality of the trees during the first 25 years was much greater.

These facts are cited here to show that the high production record of the mulched plot can not be credited entirely to the mulch. Nitrogenous fertilizer is necessary. The yield records and general behavior of the trees in the mulch plot of this orchard do suggest that on good orchard soil the requirement for nitrogenous fertilizer is much less than where the trees are not mulched.

The overall application of a complete fertilizer at the rate of 300 pounds per acre once in every 2 or 3 years may be suggested as a practical method of securing the maximum amount of mulch material at a minimum of cost. This is especially true during the early years of the orchard when shading from the trees and the competition of the feeding roots is less than is true of mature trees set at conventional distances.

Summary

A record of the behavior of an apple orchard of Delicious and Stayman Winesap for a period of 30 years is presented. Two systems of orchard soil management, cover crop and mulch, are compared.

At the end of 30 years, there was no significant difference in the size of the trees on the two plots.

The method of culture had no effect on the average date of full bloom.

The frost penetration of the soil during severe winters was much less under the mulch than the cover crop system.

The Stayman trees on the cover crop plot produced more fruit per tree during the 30-year period than those on the mulch plot. Conversely, the Delicious trees were slightly more productive on the mulch plot. During the period from the twenty-first to the thirtieth year, the average annual production of Stayman per acre on the cover crop plot was 499.2 bushels and on the mulch plot 406.7 bushels. During this same period the Delicious produced at the rate of 370.6 bushels on the cover crop plot and 456.2 bushels on the mulch plot.

The average yield per acre for the 10-year period 1935 to 1944, for both soil treatments and both varieties, was 433.1 bushels. For the 10-year period 1925 to 1934 it was 327.8 bushels per acre.

The size of the fruit of both varieties was larger on the mulch plot than on the cover crop plot. This was particularly true in the case of Stayman; however, the larger individual fruits from the mulched Stayman trees did not compensate for the lower yield.

Both varieties of fruit from the cover crop plot were more highly colored, though only slightly, than from the mulch plot.

For the 30-year period, the cost of producing a bushel of apples up to and including grading expense was .560 cents on the cover crop and .581 cents on the mulch plot. It is doubtful whether this difference of 2 cents per bushel in growing cost is significant.

Spraying was the largest single item of expense on both plots. Harvesting expense ranked second on the cover crop plot and soil management charges third. On the mulch plot, soil management expenses ranked second in importance and harvesting costs third.

During the last 20 years of this 30-year period, the only years when weather conditions seriously depressed the yield were in 1927 when frost reduced yields and in 1929 and 1943 when Delicious did not set normal crops.

The average annual value of the fruit per tree on the cover crop plot was $12.69 as compared with $12.27 on the mulch plot.

APPENDIX TABLE I.—Twelve-year record of production costs per tree of Stayman and Delicious apples under cover crop system. Orchard C. 1915-1944.

Costs	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924
	Dol.	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*
Man labor per hour	0.20	0.20	0.25	0.30	0.36	0.40	0.40	0.33	0.35	0.35
Team labor per hour	.20	.20	.30	.30	.36	.40	.40	.33	.35	.35
Tractor per hour										
Tractor operator per hour										
Tree	.10									
Planting tree	.033									
Cultivation—man and team	.223	.154	.333	.167	.262	.274	.40	.219	.213	.252
Cultivation—man and tractor										
Miscellaneous hand labor	.025	.162	.026					.048		.015
Pruning and disposing of brush		.004	.005		.022	.025	.038	.038	.084	.061
Tree guards		.10								
Cover crop seed and drilling	.164	.062	.042	.083	.135	.052	.146	.083	.087	.141
Number of spray applications		1.00	1.00	1.00	1.00	2.00	5.00	5.00	6.00	6.00
Spraying, including labor, machine, and material		.022	.018	.028	.062	.175	.182	.209	.58	.69
Fertilizer and application									.039	.039
Interest and taxes	.288	.352	.414	.478	.54	.635	.744	.810	.91	.919
Thinning										
Picking							.04	.082	.163	.224
Hauling to storage							.01	.02	.039	.067
Rental of small tools and crates	.01	.01	.01	.01	.01	.01	.042	.054	.071	.098
Grading							.02	.043	.084	.144
Supervision	.169	.169	.169	.194	.194	.194	.316	.316	.316	.316
Total cost per tree	1.012	1.035	1.017	.96	1.225	1.365	1.938	1.922	2.586	2.966
Average yield per tree in pounds							19.40	47.50	89.30	153.40
Cost of production per bushel (48 pounds*)							4.795	1.942	1.392	.926

APPENDIX TABLE I (continued).—Thirty-year record of production costs per tree of Stayman and Delicious apples under cover crop system. Orchard C. 1915-1944

Costs	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934
	Dol.	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*
Man labor per hour	0.35	0.35	0.35	0.40	0.40	0.40	0.30	0.30	0.25	0.25
Team labor per hour	.35	.35	.35	.35	.35	.35	.30	.30	.25	.25
Tractor per hour							.85	.85	.85	.85
Tractor operator per hour							.40	.40	.40	.40
Tree										
Planting tree										
Cultivation—man and team	.289	.198	.213	.588	.603	.054				
Cultivation—man and tractor							.217	.271	.171	.35
Miscellaneous hand labor				.609	.104	.174	.036	.136	.085	.227
Pruning and disposing of brush	.106	.243	.388	.343	.357	.52	.450	.331	.443	.523
Tree guards										
Cover crop seed and drilling	.217	.12	.098	.098	.124	.129	.057	.082	.093	.337
Number of spray applications	6.00	5.00	7.00	6.00	6.00	6.00	6.00	6.00	8.00	7.00
Spraying, including labor, machine, and material	.961	.798	1.621	1.193	1.871	1.418	.956	1.219	1.686	1.284
Fertilizer and application	.039	.05	.05	.062	.062	.281	.053	.05	.043	.05
Interest and taxes	.916	.462	.277	.282	.29	.293	.295	.318	.313	.289
Thinning			.502	.20	.113	.391	.269	.385	.255	.636
Picking	.397	.676	.596	.407	.511	.86	.64	.57	.54	.537
Hauling to storage	.143	.244	.214	.094	.159	.297	.277	.24	.162	.193
Rental of small tools and crates	.170	.266	.238	.116	.172	.29	.340	.303	.25	.292
Grading	.306	.522	.46	.204	.344	.645	.615	.538	.378	.451
Supervision	.422	.422	.422	.422	.422	.44	.44	.46	.46	.46
Total cost per tree	3.966	4.001	5.079	4.618	5.132	5.79	4.64	4.91	4.88	5.63
Average yield per tree in pounds	326.70	556.50	490.30	195.50	330.80	619.30	737.70	646.40	518.20	618.40
Cost of production per bushel (48 pounds*)	.581	.345	.499	1.133	.744	.449	.302	.365	.452	.437

APPENDIX TABLE I (concluded).—Thirty-year record of production costs per tree of Stayman and Delicious apples under cover crop system. Orchard C. 1915-1944

Costs	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	Totals 1935 to 1944	Totals 1915 to 1944	30-year average	Percent
	Dol.	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*				
Man labor per hour	0.25	0.30	0.35	0.35	0.35	0.35	0.35	0.40	0.50	0.55	.....	.....	0.341	.....
Team labor per hour	.25	.30	.35	.35	.35	.35	.35	.40	.50	.50	.....	.....	.336	.....
Tractor per hour	.80	.80	.80	.80	.80	.80	.80	.80	.80	80	.....	.....	814	.....
Tractor operator per hour	.40	.40	.40	.40	.40	.40	.40	.40	.50	55	.....	.....	.418	.....
Tree	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	100	.003	.07
Planting tree	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	033	.001	.03
Cultivation—man and team	.136	.123	.096	.700	.589	.366	.398	.527	.091	1.182	4.208	8.650	.288	6.37
Cultivation—man and tractor	.218	.327	.218	.218	.109	.109	.400	.182	.145	145	2.071	3.080	.103	2.27
Miscellaneous hand labor	.011	.....	.016	.....	.....	.....	.....	.....	.....	.....	.027	1.674	.056	1.23
Pruning and disposing of brush	.523	1.384	1.336	1.221	1.241	.811	.907	1.036	1.082	1.344	10.885	14 866	496	10.95
Tree guards	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.100	.003	.07
Cover crop seed and drilling	.304	.259	.261	.200	.122	.180	.284	.336	.216	.440	2.602	4.952	.165	3 65
Number of spray applications	9.00	9.00	11.00	8.00	8.00	9.00	8.00	8.00	8 00	8 00	.....	.....	.....	.....
Spraying, including labor, machine, and material	1.565	1.576	1.598	1.596	1.447	1.591	1.659	1.610	1.929	1.764	16 335	31.308	1.044	23.07
Fertilizer and application	.069	.094	.058	.056	.103	.090	.249	.074	.074	078	.945	1.763	.059	1.30
Interest and taxes	.282	.285	.290	.290	.294	.294	.295	.295	.298	.295	2.918	12.743	.425	9.39
Thinning	.341	.614	.370	.147	1.193	.557	.954	.327	.000	1.591	6.094	8.845	.295	6.52
Picking	.633	.635	.592	.880	.931	.706	.803	1.020	.934	1.805	8.939	15.182	.506	11.19
Hauling to storage	.229	.229	.207	.308	.391	.247	.255	.306	.280	.525	2.977	5.136	.171	3.78
Rental of small tools and crates	.338	.288	.232	.327	.406	.270	.277	.288	.221	.362	3.010	5.772	.192	4.25
Grading	.532	.508	.444	.660	.838	.530	.000	.574	.467	.903	5.456	10.210	.340	7.52
Supervision	.460	.460	.460	.460	.460	.460	.460	.460	.460	.460	4.600	11.323	.377	8.34
Total cost per tree	5.641	6.782	6.178	7.063	8.124	6.211	6.941	7.036	6.197	10.894	71.067	135.737	4.524	.....
Average yield per tree in pounds	729 6	609.5	473.7	703.7	893.6	564.7	583 2	611.8	448.1	787 9	6,405.9	11,755.3	391.8	.....
Cost of production per bushel (48 pounds*)	.371	.534	.626	.482	.436	.528	.571	.552	.664	.644	.....	.....	.560	.....

*At the outset of this experiment 48 pounds was the legal weight of a bushel of apples in Ohio; hence, this weight has been used throughout the experiment.

APPENDIX TABLE II.—Thirty-year record of production costs per tree of Stayman and Delicious apples under mulch system. Orchard C. 1915-1944

Costs	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924
	Dol.	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*
Man labor per hour	0.20	0.20	0 25	0.30	0.36	0.40	0.40	0.33	0.35	0.35
Team labor per hour	.20	.20	.30	.30	.36	.40	.40	.33	.35	.35
Tractor per hour										
Tractor operator per hour										
Tree	.10									
Planting tree	.05									
Mowing—man and team	.025	.033	.063	.017	.054	.092	.042	.065	.08	.068
Miscellaneous hand labor	.021	.046	.016	.04	.008	.058	.008	.041	.00	.044
Pruning and disposing of brush		.008	.005		.022	.025	.038	.038	.088	.056
Tree guards		.10								
Mulch and application	.049	.017	.031		.023	.033	.033	.375	.032	.024
Number of spray applications		1.00	1.00	1.00	1.00	2.00	5.00	5.00	6.00	6.00
Spraying, including labor, machine, and material		.022	.018	.027	.062	.175	.182	.209	.58	.69
Fertilizer and application									.039	.039
Interest and taxes	.289	352	.415	415	.478	.548	.62	.685	.746	.756
Thinning										
Picking							.035	.073	.243	.172
Hauling to storage							.008	.016	.058	.041
Rental of crates and small tools	.01	.01	.01	.01	.01	.01	.046	.057	.095	.079
Grading							.017	.038	.125	.088
Supervision	.169	.169	.169	.194	.194	.194	.316	.316	.316	.316
Total cost per tree	.713	.757	.727	.703	.851	1.135	1.345	1.913	2.402	2.373
Average yield per tree in pounds							16.80	42.80	133.60	94.40
Cost of production per bushel (48 pounds*)							3.843	2.146	.863	1.207

APPENDIX TABLE II (continued).—Thirty-year record of production costs per tree of Stayman and Delicious apples under mulch system. Orchard C. 1915-1944

Costs	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934
	Dol.	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*
Man labor per hour	0.35	0.35	0.35	0.40	0.40	0.40	0.30	0.30	0.25	0.25
Team labor per hour	.35	.35	.35	.35	.35	.35	.30	.30	.25	.25
Tractor per hour	.....	.....	.....	.....	.....	.....	.85	.85	.85	.85
Tractor operator per hour	.....	.....	.....	.....	.....	.....	.40	.40	.40	.40
Tree	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Planting tree	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Mowing—man and team	.064	.075	.076	.085	.05	.071	.041	.055	.026	.023
Miscellaneous hand labor	.024	.016	.04	.038	.033	.038	.041	037	.034	.045
Pruning and disposing of brush	.115	.239	.366	.376	.335	.433	.365	.385	.614	.557
Tree guards	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Mulch and application	.693	.016	.541	.516	.033	.866	.436	.657	.92	.....
Number of spray applications	6.00	5.00	7.00	6.00	6.00	6.00	6.00	6.00	8 00	7.00
Spraying, including labor, machine, and material	.961	.798	1.621	1.193	1.871	1.418	.956	1.219	1.686	1.284
Fertilizer and application	.039	.05	.05	.062	.062	.304	.053	.05	043	.05
Interest and taxes	.754	.484	.29	.308	.318	.32	.309	318	.313	.289
Thinning	.....	.....	.49	.189	.13	.229	.293	365	.182	.591
Picking	.395	.519	.456	.339	.438	.649	.695	.541	.554	.695
Hauling to storage	.118	.187	.164	.078	.135	.224	.30	233	.116	.25
Rental of crates and small tools	.153	.217	.196	.107	.156	.23	368	.293	.255	.367
Grading	.254	.40	.352	.169	.293	.487	667	519	.392	.583
Supervision	.422	.422	.422	.422	.422	.482	.46	.46	.46	.46
Total cost per tree	3.992	3 423	5.064	3.882	4.276	5.75	4 99	5.13	5.64	5.19
Average yield per tree in pounds	271.00	427.50	375.50	163.00	280.80	467.00	800.70	622.70	519.20	800.00
Cost of production per bushel (48 pounds*)	.707	.384	.647	1.143	.731	.591	.299	.396	.510	.312

APPENDIX TABLE II (concluded).—Thirty-year record of production costs per tree of Stayman and Delicious apples under mulch system. Orchard C. 1915-1944

Costs	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	Totals 1935 to 1944	Totals 1915 to 1944	30-year average	Percent of cost
	Dol.	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*	*Dol.*				
Man labor per hour	0.25	0.30	0.35	0.35	0.35	0.35	0.35	0.40	0.50	0.55	.....	.....	.341	.....
Team labor per hour	.25	.30	.35	.35	.35	.35	.35	.40	.50	.50	.....	.....	.336	.....
Tractor per hour	.80	.80	.80	.80	.80	.80	.80	.80	.80	.80	.....	.....	.814	.....
Tractor operator per hour	.40	.40	.40	.40	.40	.40	.40	.40	.50	.55	.....	.....	.418	.....
Tree	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.100	.003	.07
Planting tree	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.050	.002	.04
Mowing—man and team	.131	.143	.318	.191	.271	.127	.111	.127	.114	.123	1.656	2.761	.092	2.04
Miscellaneous hand labor	.....	.....	.016	.....	.....	.....	.....	.....	.....	.....	.016	.644	.021	.47
Pruning and disposing of brush	.431	1.384	1.360	1.237	1.575	.811	.907	1.036	1.082	1.345	11.168	15.233	.508	11.23
Tree guards	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.100	.003	.07
Mulch and application	1.583	2.136	.000	1.557	.927	.941	.527	1.309	1.273	1.486	11.739	17.034	.568	12.56
Number of spray applications	9.00	9.00	11.00	8.00	8.00	9.00	8.00	8.00	8.00	8.00	.....	.....	.....	.....
Spraying, including labor, machine, and material	1.565	1.555	1.598	1.666	1.510	1.660	1.731	1.680	2.013	1.840	16.818	31.790	1.060	23.44
Fertilizer and application	.069	.095	.058	.055	.103	.090	.249	.074	.074	.078	.945	1.786	.059	1.32
Interest and taxes	.282	.285	.290	.290	.294	.295	.295	.295	.298	.295	2.919	11.926	.397	8.79
Thinning	.239	.614	.334	.207	1.209	.350	.955	.327	.000	1.145	5.380	7.849	.262	5.79
Picking	.575	.785	.532	.707	.939	.762	.836	1.129	.744	1.820	8.829	14.633	.488	10.79
Hauling to storage	.207	.283	.186	.247	.394	.267	.266	.338	.223	.531	2.942	4.870	.162	3.59
Rental of crates and small tools	.310	.348	.212	.269	.409	.288	.287	.317	.183	.365	2.988	5.667	.189	4.18
Grading	.483	.674	.399	.530	.845	.572	.000	.635	.372	.910	5.420	9.804	.327	7.23
Supervision	.460	.460	.460	.460	.460	.460	.460	.460	.460	460	4.600	11.385	.380	8.39
Total cost per tree	6.335	8.762	5.763	7.416	8.936	6.623	6.624	7.727	6.836	10.398	75.420	135.632	4.521	.....
Average yield per tree in pounds	662.3	753.9	425.2	565.4	900.9	610.0	607.8	667.2	357.1	794.7	6,344.5	11,359.5	378.7	.....
Cost of production per bushel (48 pounds*)	.459	.558	.650	.629	.476	.521	.523	.545	.919	.628	.....	.....	.581	.....

*At the outset of this experiment 48 pounds was the legal weight of a bushel of apples in Ohio; hence, this weight has been used throughout the experiment.